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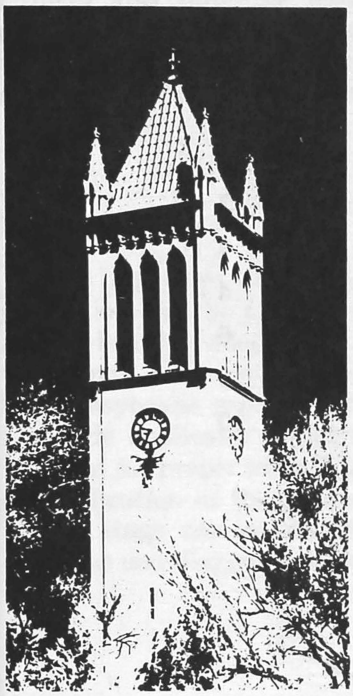

Stages of Soybean Development

by

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Soybean development is a continuous process that begins when a seed germinates and is completed when a mature seed is ready for harvest. During its life, the soybean plant is exposed to many factors that may encourage or retard its development and productivity. Some factors are controlled by nature, such as wind, rain, hail, and frost. But farmers also influence soybean development and productivity by application of pesticides and fertilizers or by the timing and methods of planting, cultivation, and other cultural practices.

A soybean plant's response to the conditions that it encounters depends on its stage of development. For example, the ability of a soybean plant to recover from leaf injury due to hail, insects, or postemergence herbicides is greater if the injury occurs before flowering rather than after flowering.

Benefits and financial returns from application of herbicides, insecticides, fertilizers, and other chemicals can be influenced by stage of plant development when the material is applied.

Purpose of Stage Descriptions

It is important that persons involved in soybean production use the same terminology when discussing soybean development. An herbicide manufacturer may recommend application of the product before soybeans reach the 6-leaf stage. Unless the herbicide applicator understands which leaves are included for proper identification of the 6-leaf stage, misapplication of the product can occur. The "full-bloom" stage can be interpreted differently unless everyone uses the same description of that stage.

Stages of soybean development described and illustrated in this publication were developed to aid communication among farmers, agribusiness representatives, extension personnel, teachers, and researchers. The descriptions are intended to be objective and precise so that minimal variation will occur among persons identifying the stage of a plant. They can be used with any soybean variety grown at any location. The descriptions can be used to describe a single plant or a field of soybeans.

Variation in Soybean Development

Variation in the relationship between vegetative and reproductive development is common for soybean plants. Planting date, variety, location, and weather can all influence the amount of stem and leaf tissue that has developed when flowering begins.

There is a major difference in plant development between indeterminate and determinate soybean varieties. Indeterminate varieties generally have achieved less than half their final height when flowering begins. Indeterminate plants grow taller and produce branches while flowering, pod development, and seed development are taking place. Pod and seed development on the lower part of the indeterminate plant are more advanced than on the top portion. The top of the indeterminate plant generally has smaller leaves than those lower on the plant, and there are only a few pods at the terminal node.

Determinate varieties generally grow very little in height after flowering begins. Flowering occurs about the same time in the top and bottom of the plant; therefore, pod and seed development are about the same throughout the plant. The determinate plant has a terminal leaf on the main stem that is about the same size as lower ones on the plant. The terminal node on the main stem usually bears a long flowering stalk or raceme, which has a number of pods.

Separate descriptions are used to identify stages of vegetative and reproductive development. Therefore, variation in the relationship between vegetative and reproductive development does not influence the staging procedure.

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Node Identification

Determination of vegetative and reproductive stages requires node identification. A node is the part of the stem where the leaf develops (fig. 1). When a leaf drops from the plant, the node can be identified by a small scar that remains on the stem (fig. 2). Nodes, not leaves, are used for stage determination because they are permanent.

The cotyledonary nodes are the first nodes located directly opposite each other on the lower part of the main stem (figs. 1 and 2). The cotyledons are part of the seed, and emerge from the soil as the seedling develops.

The two unifoliolate nodes are located directly opposite each other, immediately above the cotyledonary nodes (figs. 1 and 2). The leaf at each unifoliolate node is a single leaflet, in contrast to the trifoliolate leaves, which consist of three leaflets.

All nodes above the unifoliolate nodes have trifoliolate leaves. The trifoliolate nodes alternate from one side to the other up the main stem (fig. 1).

Nodes on the main stem that have or have had a fully developed leaf are counted in determining stage of development. Young leaves have three leaflets that resemble cylinders (fig. 3). As leaf development progresses, each leaflet unrolls until the edges separate and the leaflet begins to flatten out (fig. 4). To determine when the leaf is fully developed, leaf development is examined at the node immediately above. A leaf is considered fully developed (node is counted) when the leaf at the node above has unrolled sufficiently so that the two edges of each leaflet are not touching.

The soybean plant terminates its growth on the main stem with a terminal node bearing a trifoliolate leaf. At the terminal node on the main stem, the leaf is considered fully developed when the leaflets are flat and similar in appearance to older leaves on the plants. On indeterminate soybeans, the terminal node bears a smaller leaf than those lower on the plant (fig. 5). On determinate soybeans, the terminal node bears a leaf about equal in size to those lower on the plant (fig. 6).

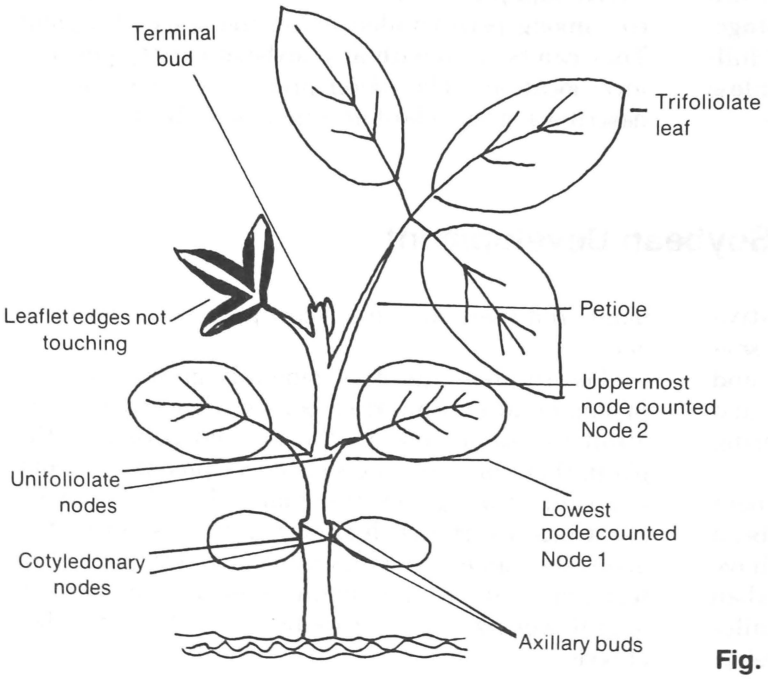


Fig. 1. Parts of a soybean plant at the second-node (V2) stage.

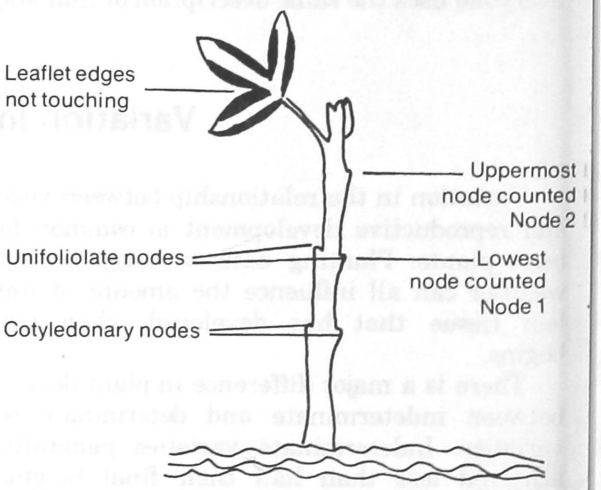


Fig. 2. Identification of nodes on a soybean plant at the second-node (V2) stage with the cotyledons, unifoliolate leaves, and first trifoliolate leaf removed.

Vegetative Stages

Vegetative stages are described from the time the plant emerges from the soil. After the cotyledon (VC) stage, nodes are counted beginning with the unifoliolate nodes. The unifoliolate nodes are technically two separate nodes, but they are counted as one because they occur at the same position and time on the main stem.

Only nodes on the main stem are counted. Nodes

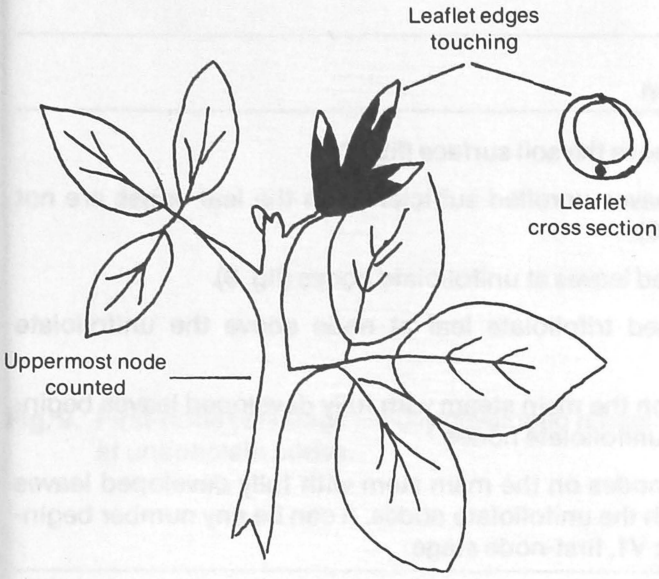


Fig. 3. Identification of the uppermost node with a fully developed leaf (uppermost node counted).

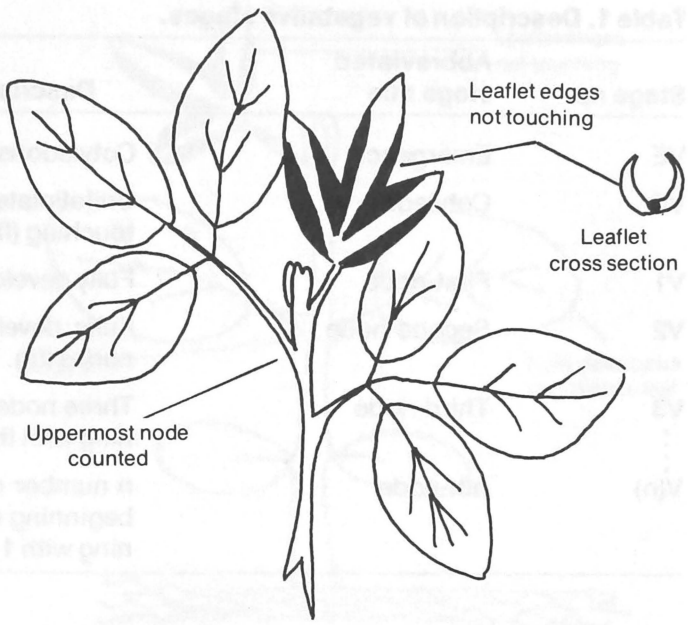


Fig. 4. Identification of the uppermost node with a fully developed leaf (uppermost node counted).

on branches should not be considered. If the main stem is broken or cut off, new branches that develop should not be used to determine vegetative stages. Development of the new growth will be behind that of a main stem that has not been cut off.

Each stage description (table 1) is given a vegetative stage (V) designation and an abbreviated title to facilitate communication. Vegetative stage numbers are determined by counting the number of nodes on the main stem, beginning with the unifoliolate nodes, that have or have had a fully developed leaf.

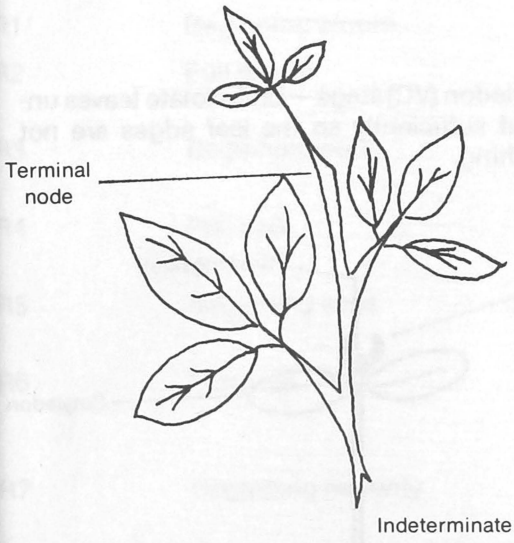


Fig. 5. Terminal node on the main stem of an indeterminate variety. The terminal leaf is smaller than leaves lower on the plant.

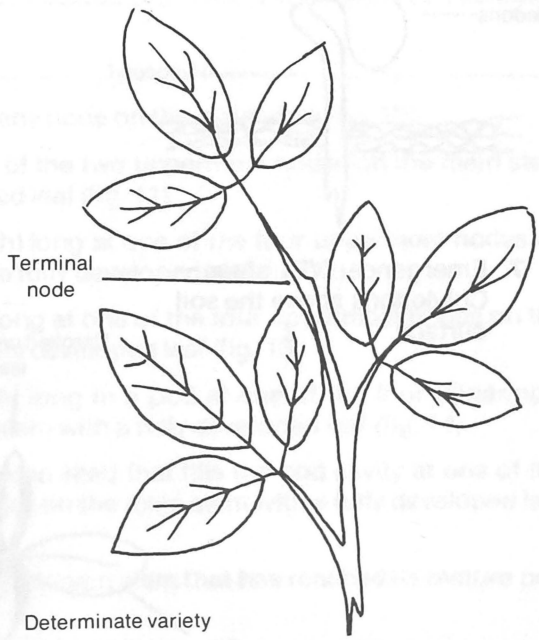


Fig. 6. Terminal node on the main stem of a determinate variety. The terminal leaf is similar in size to leaves lower on the plant.

Table 1. Description of vegetative stages.

Stage no.	Abbreviated stage title	Description
VE	Emergence	Cotyledons above the soil surface (fig. 7).
VC	Cotyledon	Unifoliolate leaves unrolled sufficiently so the leaf edges are not touching (fig. 8).
V1	First-node	Fully developed leaves at unifoliolate nodes (fig. 9).
V2	Second-node	Fully developed trifoliolate leaf at node above the unifoliolate nodes (fig. 1).
V3	Third-node	Three nodes on the main steam with fully developed leaves beginning with the unifoliolate nodes.
⋮		
V(n)	nth-node	n number of nodes on the main stem with fully developed leaves beginning with the unifoliolate nodes. n can be any number beginning with 1 for V1, first-node stage.

Reproductive Stages

Reproductive stages are based on flowering, pod development, seed development, and plant maturation. Each stage description is given a reproductive stage (R) number and an abbreviated title (table 2).

The main stem must be used for determining reproductive stages. When the main stem of a plant is broken or cut off, reproductive development on the new branches may be retarded.

Stages R1 and R2 (table 2) may occur simultaneously in determinate varieties because flowering begins at the upper nodes of the main stem. The two stages are approximately 3 days apart for indeterminate varieties, in which flowering begins in the lower portion of the main stem and progresses upward.

Pods reach nearly full size before the seed begins to develop rapidly. Pod measurements for R3 and R4 are made from the base of the calyx (leaf-like tissue

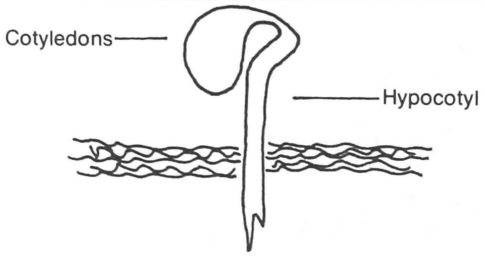
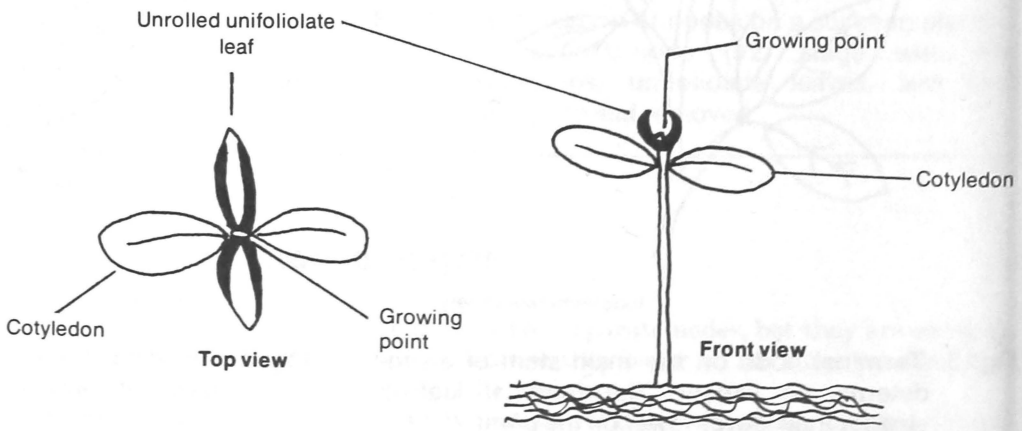


Fig. 7. Emergence (VE) stage—Cotyledons above the soil surface.

Fig. 8. Cotyledon (VC) stage—Unifoliolate leaves unrolled sufficiently so the leaf edges are not touching.



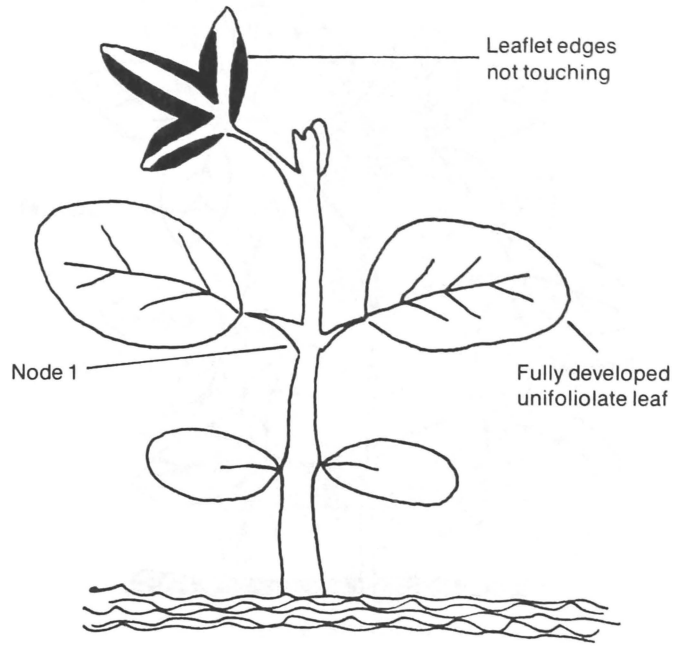


Fig. 9. First-node (V1) stage—Fully developed leaves at unifoliolate nodes.

at the bottom of the pod) to the tip of the pod (figs. 12 and 13). When pods are 2 cm (centimeters) long at R4, the pod cavity in which each seed will develop is outlined by a white membrane. At R6 the seed has enlarged enough to cover the entire membrane (fig. 15). The seed continues to get thicker after R6 until its full size is achieved.

As the soybean plant matures, leaf and pod yellowing generally occur simultaneously. In some circumstances, however, leaves may remain green after the pods have attained their mature pod color.

Soybean varieties differ in their mature pod color. The most common colors are brown and tan, but soybean lines are known that have black pods.

Table 2. Description of reproductive stages.

Stage no.	Abbreviated stage title	Description
R1	Beginning bloom	One open flower at any node on the main stem (fig. 10).
R2	Full bloom	Open flower at one of the two uppermost nodes on the main stem with a fully developed leaf (fig. 11).
R3	Beginning pod	Pod 5 mm (3/16 inch) long at one of the four uppermost nodes on the main stem with a fully developed leaf (fig. 12).
R4	Full pod	Pod 2 cm (¾ inch) long at one of the four uppermost nodes on the main stem with a fully developed leaf (fig. 13).
R5	Beginning seed	Seed 3mm (1/8 inch) long in a pod at one of the four uppermost nodes on the main stem with a fully developed leaf (fig. 14).
R6	Full seed	Pod containing a green seed that fills the pod cavity at one of the four uppermost nodes on the main stem with a fully developed leaf (fig. 15).
R7	Beginning maturity	One normal pod on the main stem that has reached its mature pod color.
R8	Full maturity	Ninety-five percent of the pods that have reached their mature pod color. Five to ten days of drying weather are required after R8 before the soybeans have less than 15 percent moisture.

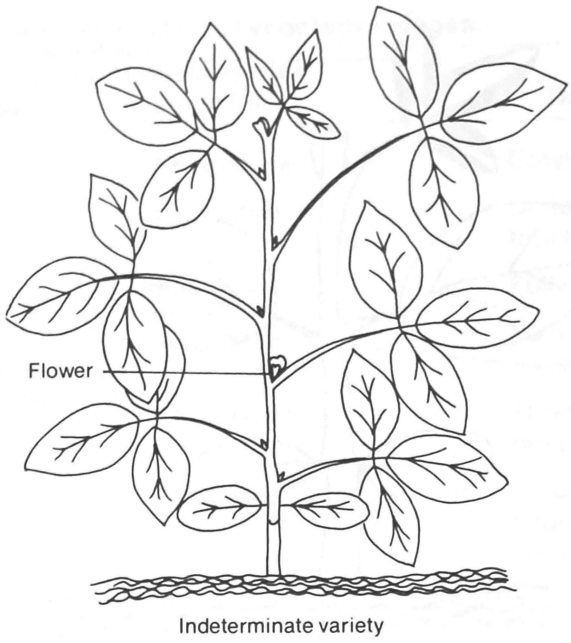
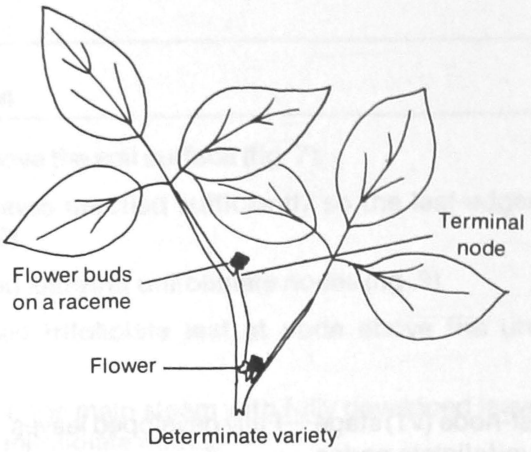
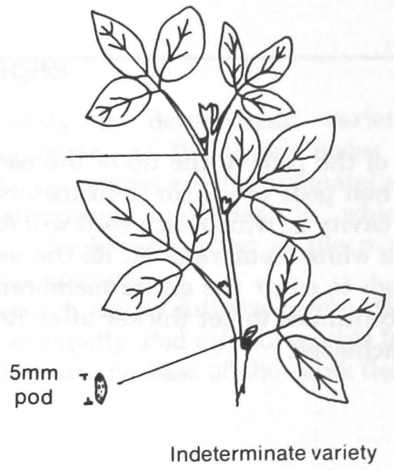


Fig. 10. Beginning bloom (R1) stage—One open flower at any node on the main stem. With indeterminate varieties less than one-half of the nodes on the main stem have developed when flowering begins. Determinate varieties begin flowering when most or all of the nodes on the main stem have developed. Flowering can begin at one of the two uppermost nodes on the main stem for determinate varieties.





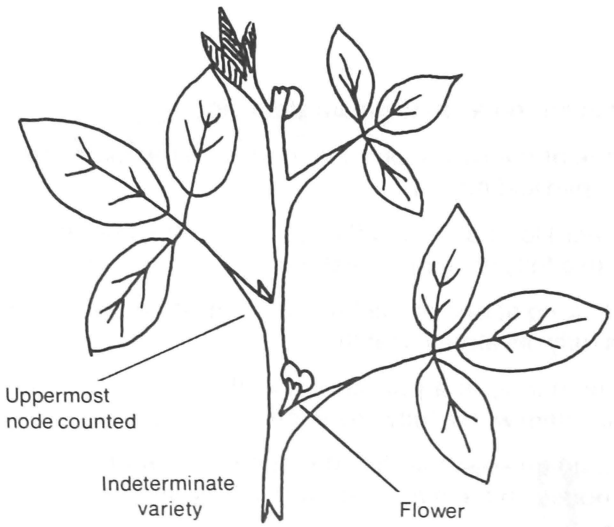


Fig. 11. Full bloom (R2) stage—Open flower at one of the two uppermost nodes on the main stem with a fully developed leaf. Stages R1 and R2 may occur simultaneously with determinate varieties. Figure 10 represents both R1 and R2 for determinate varieties.

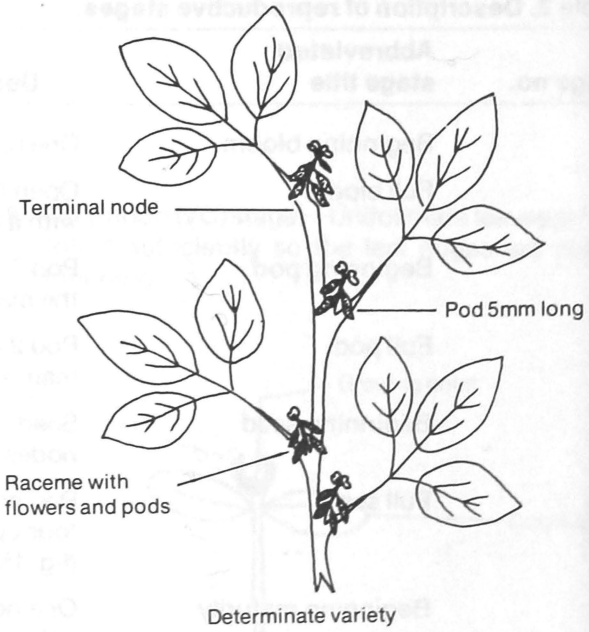
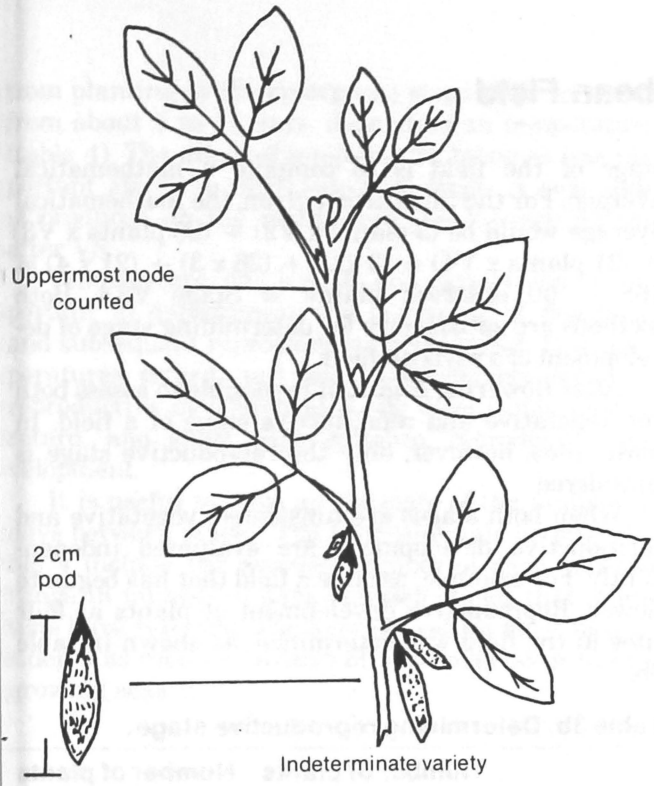


Fig. 12. Beginning pod (R3) stage—Pod 5mm (3/16 inch) long at one of the four uppermost nodes on the main stem with a fully developed leaf.



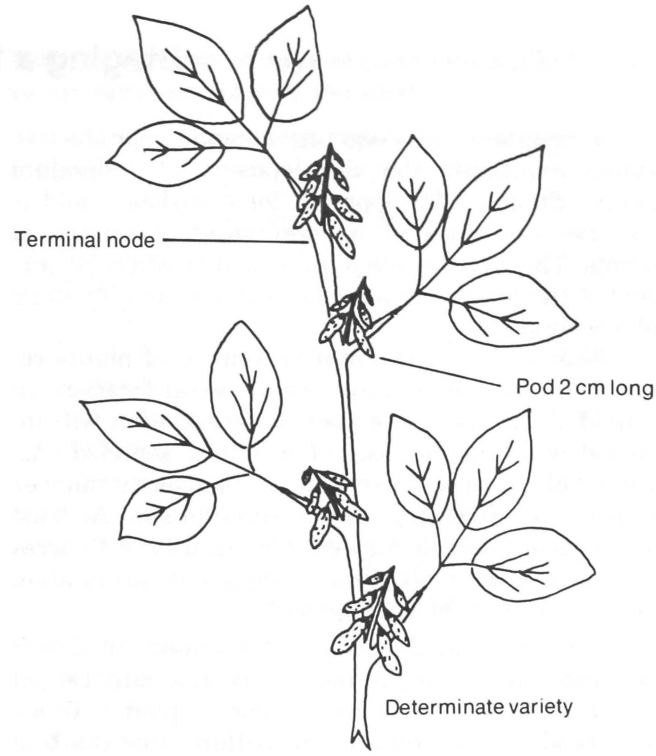


Fig. 13. Full pod (R4) stage—Pod 2cm (¾ inch) long at one of the four uppermost nodes on the main stem with a fully developed leaf.

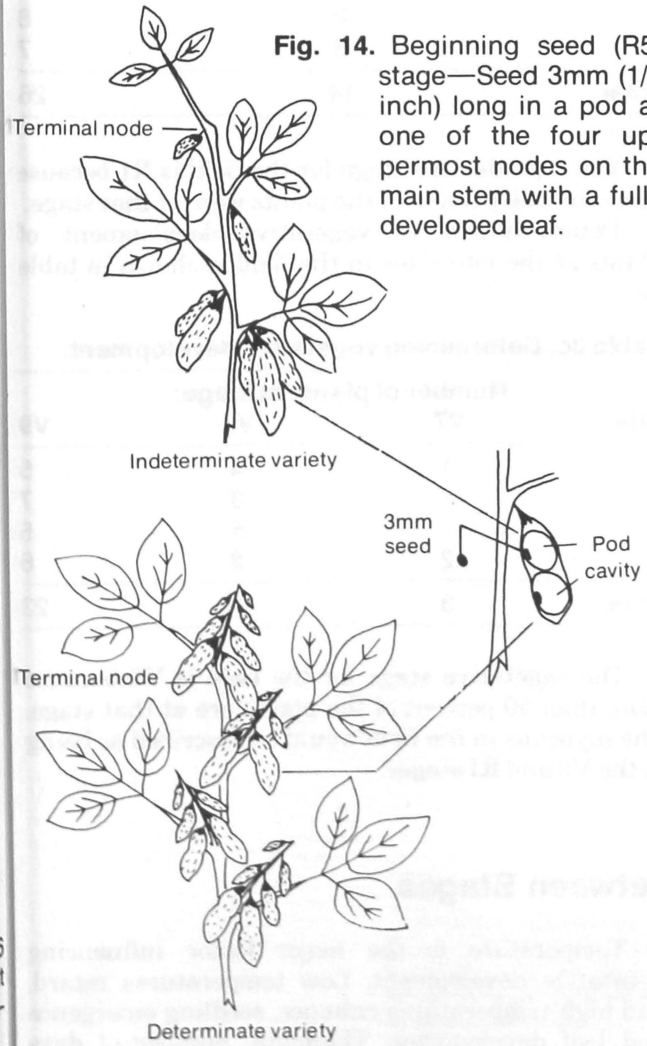


Fig. 14. Beginning seed (R5) stage—Seed 3mm (1/8 inch) long in a pod at one of the four uppermost nodes on the main stem with a fully developed leaf.

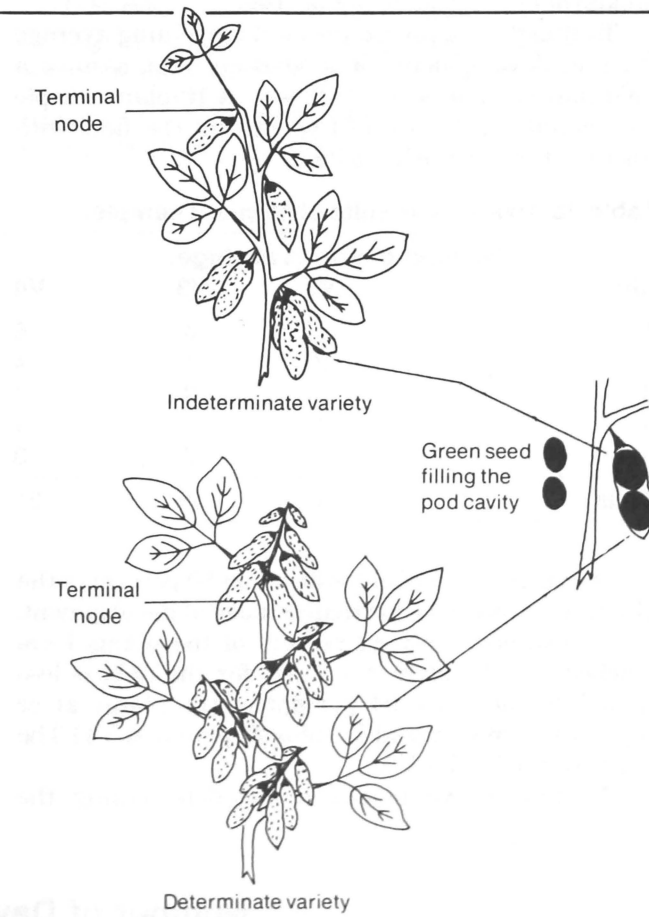


Fig. 15. Full seed (R6) stage—Pod containing a green seed that fills the pod cavity at one of the four uppermost nodes on the main stem with a fully developed leaf.

Staging a Soybean Field

Descriptions of vegetative and reproductive stages represent the development of individual plants. Stage of development for a soybean field is the average stage of a representative sample of plants. The average stage of a field is when 50 percent of the plants are at or beyond a particular stage of development.

Obtaining a representative sample of plants requires inspection of plants from several locations in a field. Accuracy of the stage determination will increase with the number of locations sampled. Accuracy also will improve with an increasing number of plants evaluated at each inspection site. At least one 10-plant sample for every 5 hectares or 10 acres should be used to obtain an adequate determination of average stage of development.

Plants evaluated for stage of development should be randomly selected at each inspection site. Do not select only the largest, most vigorous plants. To assure random selection of plants within a row, it is best to evaluate consecutive plants that have an undamaged main stem. Plants with the main stem broken or cut off should not be used.

To illustrate a procedure for determining average stage of development for a soybean field, assume a field that has not begun to flower. A 10-plant sample was evaluated at each of five sites in the field with the results shown in table 3a.

Table 3a. Example results of 10-plant sample.

	Number of plants at stage:		
Site	V2	V3	V4
1	-	4	6
2	2	4	4
3	-	3	7
4	1	8	1
5	-	7	3
Total	3	26	21

The stage for the field is based on 50 percent of the plants at or beyond a particular stage of development. In our example, only 42 percent of the plants have reached V4; therefore, the stage for the field is less than V4. There are 94 percent of the plants at or beyond V3 (26 plants at V3 plus 21 plants at V4). The stage for the field is V3.

An alternative procedure for determining the stage of the field is to compute a mathematical average. For the illustration given, the mathematical average would be (3 plants x V2) + (26 plants x V3) + (21 plants x V4) = (3 x 2) + (26 x 3) + (21 x 4) = 168 ÷ 50 observed plants = Stage V3.4. Both methods are satisfactory for determining stage of development of a soybean field.

After flowering begins, it is possible to assess both the vegetative and reproductive stage of a field. In most cases, however, only the reproductive stage is considered.

When both stages are considered, vegetative and reproductive development are evaluated independently. For example, assume a field that has begun to flower. Reproductive development of plants at four sites in the field was determined as shown in table 3b.

Table 3b. Determining reproductive stage.

Site	Number of plants with no flowers	Number of plants at R1
1	3	7
2	6	4
3	2	8
4	3	7
Total	14	26

The reproductive stage for the field is R1 because more than 50 percent of the plants were at that stage.

Determination of vegetative development of plants at the four sites in the field is shown in table 3c.

Table 3c. Determining vegetative development.

	Number of plants at stage:		
Site	V7	V8	V9
1	1	4	5
2	-	3	7
3	-	5	5
4	2	2	6
Total	3	14	23

The vegetative stage for the field is V9 because more than 50 percent of the plants are at that stage. The soybeans in the field would be described as being in the V9 and R1 stages.

Number of Days Between Stages

Soybean development can be influenced by temperature, day length, variety, and other factors. Consequently, there can be considerable variation in the number of days between stages.

Temperature is the major factor influencing vegetative development. Low temperatures retard, and high temperatures enhance, seedling emergence and leaf development. Therefore, number of days

from planting to the emergence stage (VE) can vary from about 5 to 15 days, depending on temperature (table 4). The effect of temperature becomes less important after the fifth-node (V5) stage. A new node is produced on the main stem about every 3 days after V5.

Temperature, day length, and variety can be important in determining the beginning of flowering and subsequent reproductive development. Low temperatures retard, and high temperatures enhance, reproductive development. Long days (short nights) retard, and short days enhance, reproductive development.

It is useful to have an estimate of the number of days between stages. The time intervals listed in table 4 include the average number of days and the range in number of days between stages that scientists have reported. The average values must be considered as rough estimates of what may occur in any growing season.

Table 4. Number of days required for a plant to develop from one stage to the next.

Stages	Average number of days	Range in number of days**
Vegetative Stages		
Planting to VE	10	5-15
VE to VC	5	3-10
VC to V1	5	3-10
V1 to V2	5	3-10
V2 to V3	5	3-8
V3 to V4	5	3-8
V4 to V5	5	3-8
V5 to V6	3	2-5
Time interval between all vegetative stages after V5	3	2-5
Reproductive Stages		
R1 to R2	0*, 3	0-7
R2 to R3	10	5-15
R3 to R4	9	5-15
R4 to R5	9	4-26
R5 to R6	15	11-20
R6 to R7	18	9-30
R7 to R8	9	7-18

*R1 and R2 generally occur simultaneously in determinate varieties. The time interval between R1 and R2 for indeterminate varieties is about 3 days.

**Data are from studies conducted in the United States. The range may differ for cooler or more tropical climates.

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